

## Colligative Properties

Answer the following questions on a separate sheet of paper.

- 1) At 63.5°C, the vapor pressure of H<sub>2</sub>O is 175 torr, and that of ethanol (C<sub>2</sub>H<sub>5</sub>OH) is 400 torr. A solution is made by mixing equal masses of H<sub>2</sub>O and C<sub>2</sub>H<sub>5</sub>OH. What is the total vapor pressure of the solution?
- 2) (a) Calculate the vapor pressure of water above a solution prepared by adding 22.5 g of lactose (C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>) to 200.0 g of water at 338 K. The vapor pressure of water at 338 K is 187.5 torr.  
(b) Calculate the mass of propylene glycol (C<sub>3</sub>H<sub>8</sub>O<sub>2</sub>) that must be added to 0.340 kg of water to reduce the vapor pressure by 2.88 torr at 40°C. The vapor pressure of water at 40°C is 55.3 torr.
- 3) Calculate the freezing and boiling points of each of the following solutions:  
(a) 0.22 m glycerol (C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>) in ethanol ( $K_b = 1.22\text{ }^{\circ}\text{C/m}$ ,  $K_f = 1.99\text{ }^{\circ}\text{C/m}$ )  
(b) 0.240 mol of naphthalene (C<sub>10</sub>H<sub>8</sub>) in 2.45 mol of chloroform ( $K_b = 3.63\text{ }^{\circ}\text{C/m}$ ,  $K_f = 4.68\text{ }^{\circ}\text{C/m}$ )  
(c) 2.04 g KBr and 4.82 g glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) in 188 g of water ( $K_b = 0.51\text{ }^{\circ}\text{C/m}$ ,  $K_f = 1.86\text{ }^{\circ}\text{C/m}$ )
- 4) What is the osmotic pressure of a solution formed by dissolving 44.2 mg of aspirin (C<sub>9</sub>H<sub>8</sub>O<sub>4</sub>) in 0.358 L of water at 25°C?
- 5) Lauryl alcohol is obtained from coconut oil and is used to make detergents. A solution of 5.00 g of lauryl alcohol in 0.100 kg of benzene freezes in 4.1°C. What is the approximate molar mass of lauryl alcohol?
- 6) Lysozyme is an enzyme that breaks bacterial cell walls. A solution containing 0.150 g of this enzyme in 210 mL of solution has an osmotic pressure of 0.953 torr at 25°C. What is the molar mass of lysozyme?
- 7) Which of the following will have the lowest total vapor pressure at 25°C? Which will have the highest vapor pressure?  
(a) Pure water (vapor pressure = 23.8 torr at 25°C)  
(b) A solution of glucose in water with  $X_{\text{glucose}} = 0.01$   
(c) A solution of sodium chloride in water with  $X_{\text{NaCl}} = 0.01$   
(d) A solution of methanol in water with  $X_{\text{methanol}} = 0.2$  [Consider the vapor pressure of both methanol (143 torr at 25°C) and water]
- 8) The freezing point of t-butanol is 25.50°C and  $K_f$  is 9.1 °C/m. Usually t-butanol absorbs water on exposure to air. If the freezing point of a 10.0 g sample of t-butanol is 24.59°C, how many grams of water are present in the sample?

- 9) From the following: pure water, solution of  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  ( $m = 0.01$ ) in water, solution of  $\text{NaCl}$  ( $m = 0.01$ ) in water, solution of  $\text{CaCl}_2$  ( $m = 0.01$ ) in water. Choose the one with:
- (a) Highest freezing point
  - (b) Lowest freezing point
  - (c) Highest boiling point
  - (d) Lowest boiling point
  - (e) Highest osmotic pressure
- 10) In the winter of 1994, record low temperatures were registered through the United States. For example, in Champaign, Illinois, a record low of  $-29^\circ\text{F}$  was registered. At this temperature can salting icy roads with  $\text{CaCl}_2$  be effective in melting in ice? Assume  $i = 3$  for  $\text{CaCl}_2$ .